RESEARCH
Original Research

Taste Exposure Increases Intake and Nutrition Education Increases Willingness to Try an Unfamiliar Vegetable in Preschool Children: A Cluster Randomized Trial

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ARTICLE INFORMATION

Article history:
Submitted 7 September 2018
Accepted 15 May 2019

Keywords:
Vegetable intake
Healthy eating intervention
Health promotion
Nutrition education
Sensory learning

https://doi.org/10.1016/j.jand.2019.05.012

ABSTRACT

Background Intake of vegetables in children remains low.

Objective To compare taste exposure (TE), nutrition education (NE) and TE+NE together on intake of an unfamiliar vegetable (*mooli*/daikon radish) in preschool-aged children.

Design Children attending 11 preschools in England were randomly assigned by clusters to four intervention conditions using a 2×2 factorial design: TE, NE, TE+NE, and no intervention (control).

Participants Two hundred nineteen children aged 2 to 5 years participated from September 2016 to June 2017.

Intervention The intervention period was 10 weeks preceded and followed by measurements of raw *mooli* intake as a snack. Preschools were randomized to receive weekly TE at snack time (n=62 children); NE (n=68) using the PhunkyFoods program; TE+NE (n=55) received both weekly taste exposures at snack and lessons from the PhunkyFoods program; and the control condition (n=34), received NE after the final follow-up measurement.

Main outcome measures Individual measured intakes of *mooli* at Week 1 (baseline), Week 12 (postintervention), and Week 24 and Week 36 (follow-ups).

Statistical analysis Differences in intakes were analyzed by cluster. Logistic regressions were conducted to examine odds ratios for intake patterns.

Results Data from 140 children with complete *mooli* intake assessments were analyzed. TE increased intake from 4.7±1.4 g to 17.0±2.0 g and this was maintained at both follow-ups. Children assigned to the NE conditions were more likely to eat some of the *mooli* than children who were not in the NE conditions (odds ratio 6.43, 95% CI 1.5 to 27.8). Combining TE and NE produced no additional benefit to intake beyond TE alone.

Conclusions Taste exposures encouraged children to eat more of the unfamiliar vegetable, whereas nutrition education encouraged children who were noneaters to try the vegetable. Both approaches were effective and can be used to produce different outcomes.
J Acad Nutr Diet. 2019;■:■-■.

DIETS CONTAINING FOODS THAT ARE RICH IN NUtrients and low in energy density such as fruits and vegetables have protective effects on health.[1] Preschool-aged children are recommended to eat a minimum of 5 portions (~200 g or 1.5 cups) of fruits and vegetables daily.[2,3] Yet more than 75% of children in the United States and Europe fail to meet this recommendation.[3-5] Evidence from reviews and meta-analyses indicate that it is more challenging to increase vegetable than fruit intake.[6,7] The bitter taste and unfamiliar texture of some vegetables may inhibit efforts to increase intake, as well as their low energy density.[8] Child eating traits such as food fussiness may also explain low vegetable intake.[9,10] Children who are fussy eaters appear to be especially resistant to eating vegetables, and it has been proposed that systematic exposure in early life is needed to encourage vegetable intake in these children.[10] Parents of fussy eaters use a variety of vegetable-specific strategies, including hiding vegetables in meals as well as food and nonfood rewards to encourage intake.[9] Food fussiness peaks between ages 2 and 5 years, yet there are few studies that investigate which strategies benefit children with food fussiness.[11,12]

Preschool provides an ideal opportunity for children to learn about healthy eating and to try new foods for the first time.[13-15] Preschools encourage healthy eating through nutrition education programs.[16] These programs are tailored to the child's age with learning activities that are designed to be fun and interactive as well as educational. However, education programs implemented in preschool tend to focus on vegetables that are already familiar to the children and their effects on unfamiliar vegetables are understudied.[17] Furthermore, the effects of these programs on actual food intake tend to be small, perhaps due to the indirect nature of the exposure.[17,18] Therefore, it has been proposed that learning about vegetables through direct experience of the taste, smell, and texture through exposure and engaging children in hands-on activities to increase familiarization will increase intake of vegetables.[19]

Repeated taste exposure is known to enhance intake of vegetables[9,20,21] via familiarization[22] and learned safety.[23] Eight to 10 taste exposures to a novel or previously disliked vegetable are sufficient to increase consumption at the group level.[24,25] However, this may not be effective at the individual level because caregivers may not achieve this number of exposures as a result of interpreting initial refusal as genuine dislike.[8,26,27] Similarly, in preschools, to avoid waste, children may not be offered vegetables that are believed to be disliked. Providing children with incentives such as tangible nonfood rewards (eg, stickers) with repeated taste exposure can increase vegetable acceptance, both in homes and in preschools.[28-30] Indeed, combining nutrition education that is specifically designed to increase knowledge about eating vegetables with taste exposures might produce a synergistic effect in increasing vegetable intake. Synergy in this context may be achieved by both encouraging children to try the taste of an unfamiliar vegetable therefore giving them direct experience of the target vegetable (eg, smell, taste, and texture) as well as by increasing their awareness of different vegetables and their benefits to health and well-being. For young children it may be important to understand why vegetables are good for them to also taste and eat them when offered. Therefore, the aim of this cluster randomized trial was to test the relative efficacy of repeated taste exposure (TE), nutrition education (NE), and a combined TE+NE intervention compared with a no-intervention control on intake of an unfamiliar vegetable in preschool-aged children. The primary hypothesis was that children would increase intake of an unfamiliar vegetable following intervention relative to control and that TE+NE would enhance intake of the vegetable more than either intervention alone relative to a control.

MATERIALS AND METHODS

Study Design

A 2×2 factorial parallel design (with a no-intervention control) was used in the present cluster randomized controlled trial (Figure 1). For ease of intervention delivery and feasibility in a preschool setting, it was decided that a cluster randomization trial was the most appropriate design. The 11 preschools agreeing to participate in the study varied in size; therefore, stratified randomization was used. The preschools were divided into three strata, with the four largest in one stratum, then the four smallest in another stratum. One preschool in each stratum was assigned to each intervention condition using an online list generator (https://www.random.org/lists): TE, NE, TE+NE, or no intervention (control). Researcher CN generated the random allocation sequence for each preschool and preschool managers chose the day and time that was most convenient for them, and thus which children would be included in the study. Preschool managers were not informed of their condition allocation until all preschools were recruited (after consent) and randomized. It was possible to conceal condition allocation between clusters but not within a cluster. Parents were given a list of potential study vegetables used during the study phase.

Preschools were offered the PhunkyFoods program (PFP; https://www.phunkyfoods.co.uk/about-us/programmes/) as an incentive to take part (normally valued at £395 per annum). They either received this during the intervention or on completion of the study. All procedures were conducted in accordance with the ethical guidelines set by the British Psychological Society and approved by the University of Leeds, School of Psychology Research Ethics Committee (no. 16-0198). The trial was preregistered with ClinicalTrials.gov (identifier: NCT03003923). The study lasted for 12 weeks (September 2016 to December 2017), including a 10-week intervention phase (plus baseline and postintervention assessment) with follow-up intake of the unfamiliar vegetable measured at Week 24 (March 2017) and Week 36 (June 2017).

Participants

Fifty-five preschools from Leeds, Brighouse, and Halifax (West Yorkshire, UK) were sent a recruitment e-mail in July 2016, followed by a telephone call. In all, 219 children were enrolled in the study; however the anticipated sample size was not fully met for the final analysis (Figure 2). The low number of children in the control condition was attributed to low attendance on different test days. Consent to participate was sought from the preschool manager at the cluster level and individually by parents using an opt-out approach. Preschool managers signed the informed consent form and children could say no and decline to participate in research activities. All children aged 2 to 5 years attending their preschool class on the agreed test day were included. They were excluded from the study in the case that they had any relevant food allergies, a medical condition that would prevent them from eating the test vegetable, or if their parents opted

> **RESEARCH SNAPSHOT**
>
> **Research Question:** To what extent do taste exposure, nutrition education, or the two strategies combined lead to increased intake of an unfamiliar vegetable (*mooli*/daikon radish) in preschool-aged children?
>
> **Key Findings:** Taste exposure encouraged children to eat more of the unfamiliar vegetable (*mooli*/daikon radish) and nutrition education encouraged children who were noneaters to try the vegetable. Each approach is effective in a different way: exposure increases consumption of an unfamiliar vegetable in children who are already eaters, whereas education may be needed as part of a more gradual approach to trying an unfamiliar vegetable in noneaters.

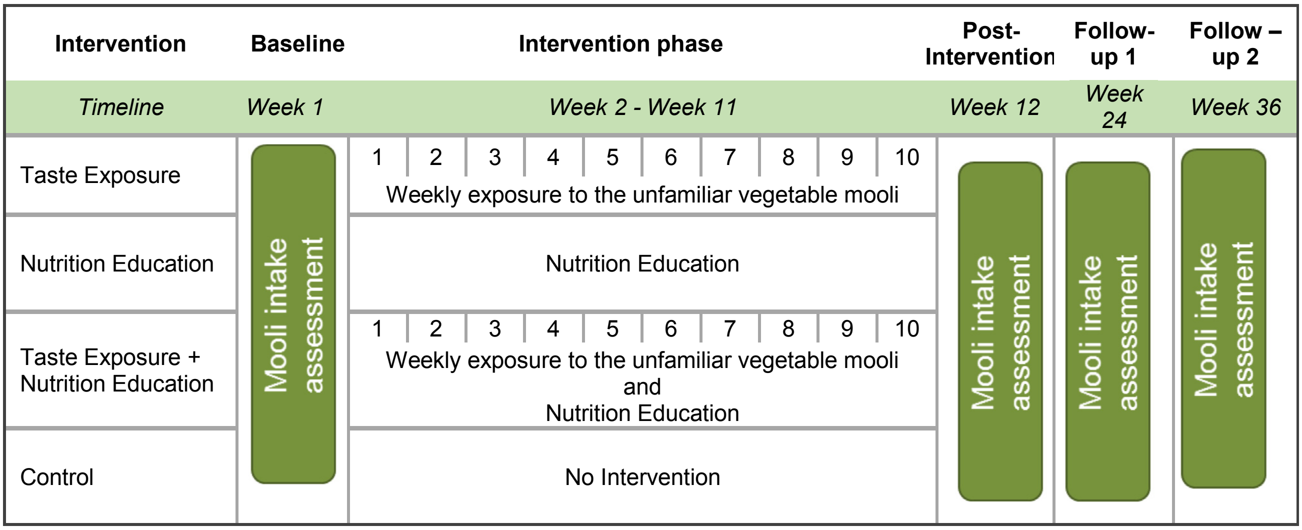

Figure 1. Design of a study testing the effectiveness of taste exposure and nutrition education on intake of an unfamiliar vegetable (*mooli*) in preschool-aged children. The intervention lasted 10 weeks and intake of *mooli* was measured for all children at baseline (Week 1), postintervention (Week 12), follow-up 1 (Week 24), and follow-up 2 (Week 36). Children in the taste exposure intervention were offered *mooli* once a week and children in the nutrition education intervention were offered Strive for 5! and Eat Well nutrition lessons from an existing PhunkyFoods education program.

out of the study (see Figure 2). Included in the final analysis were 140 children (70 boys and 70 girls) with complete intake assessments at all four time points with a mean age of 40.6±0.4 months. Preschools were eligible to take part in the case that they were not participating in other nutrition health programs and were able to commit to the time frame of the study (9 months).

Table 1 provides the baseline characteristics of children who took part in the intervention. There were no differences across intervention conditions in sex distribution or mean body mass index *z* score, but there were differences in mean age. No differences were found in baseline characteristics or intake of the children who were lost to follow-up compared with those who completed the study.

Materials: Target Unfamiliar Vegetable

During development of the intervention, all preschool managers were asked about vegetables offered to children. Based on this information a selection of seven unfamiliar vegetables, available through all seasons in the United Kingdom, were selected for a taste test (*coccinia* cluster beans, steamed beetroot, raw beetroot, marrow, cherry belle radish, and *mooli* white radish). These vegetables were tasted and independently rated by a panel of 10 researchers. The purpose of the tasting session was to identify a novel vegetable (ie, unfamiliar) that could be eaten raw (ie, not too bitter or hard) and was suitable for preschool-aged children. Through this process, *mooli* (a variety of daikon, a long white radish) was selected as the unfamiliar vegetable.

Procedure

The preschool staff members were provided with all the necessary resources and basic instructions to deliver the intervention to children in their preschools. During Week 1 baseline intake of *mooli* was measured at the prearranged snack time and children's height and weight was also measured. Over the next 10 weeks, children in the intervention conditions were offered either the TE, NE, or TE+NE intervention and children in the control condition were offered no intervention. After the intervention at Week 12 (postintervention) *mooli* intake was measured at snack time. *Mooli* intake was also recorded at two follow-up periods (Week 24 and Week 36) at the usual snack time. The intervention was delivered at the level of the preschool and outcomes measured at the individual level.

Baseline, Postintervention, and Follow-Up Intake Assessment Procedure

Intake of *mooli* was assessed at Weeks 1, 12, 24, and 36. The vegetable was offered to children at their usual snack time (mornings or afternoons) so it was assumed that children would be moderately hungry. Each vegetable portion was weighed (to the nearest 0.01 g) before and after each snack time using a digital scale (Mettler PJ4000; Mettler-Toledo LLC) by the research team. Fresh *mooli* was peeled and cut into bite-size pieces (thin ∼0.4-mm slices, in circles, semicircles, or quadrants depending on the size of the *mooli*). Snack bags were prepared and weighed for each child with a ∼40-g portion. Spare bags were prepared in case children requested more of the vegetable. Study snacks were delivered to the preschools at least 30 minutes before their snack session to allow staff time to prepare for this. Children were allowed to eat ad libitum during each snack time. Staff members were asked to ensure that children did not share their snack with others and that any leftovers were returned to the individual snack bags. Staff were advised to store the vegetable in a refrigerator or the cool bag provided and to return the bags to the cooler after consumption. This was done to reduce moisture loss. Snack bags were collected after the exposures and were reweighed immediately to calculate intake.

Intervention

For the TE and TE+NE conditions, the researcher prepared *mooli* as snacks, delivered this to each preschool, and the

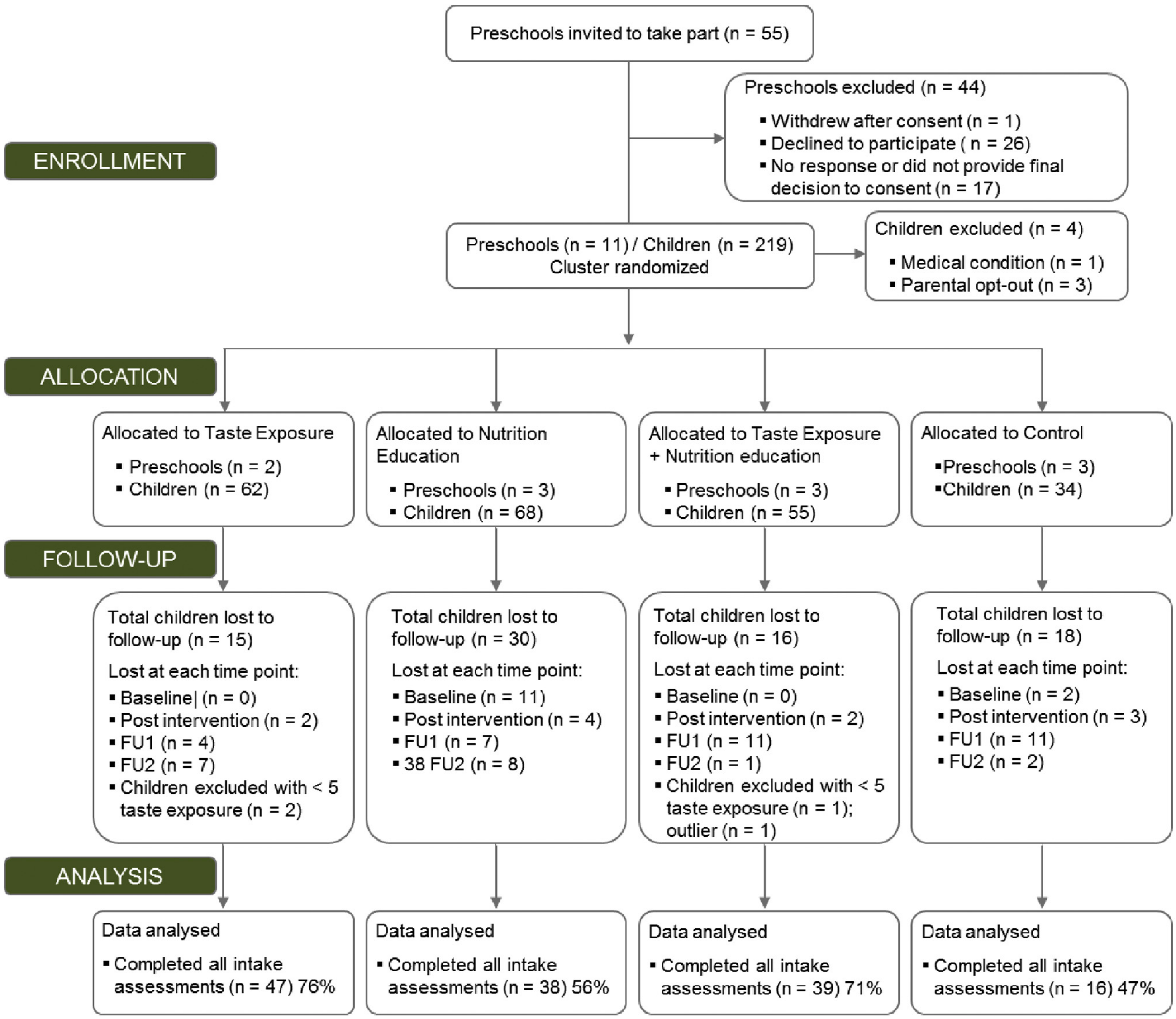

Figure 2. Flow of preschools and children through this study testing the effectiveness of taste exposure and nutrition education on intake of an unfamiliar vegetable (*mooli*) in preschool-aged children. No clusters were lost to follow-up (FU) or excluded from the analysis. Children were classified as lost to FU and excluded from the analysis in the case that they missed any intake assessment days.

snacks were provided to children by preschool staff members. The procedure for *mooli* preparation and intake were same as those on the intake assessment days (see above). TE involved offering *mooli* during usual snack time once per week, every week for 10 weeks (Weeks 2 to 11). The vegetable snack was offered in preweighed 40-g portions using individual snack bags labeled for each child.

For the NE clusters, preschool staff members were trained by the PhunkyFoods team to deliver the existing nutrition education program (www.phunkyfoods.com). The PFP is designed for preschool-aged children and follows the English Early Years Foundation Stage Framework, promoting learning through planned purposeful play, and a mix of adult-led and child-initiated activities. PFP provides preschools with ideas and inspiration for classroom carousel play activities (eg, stories, role play, and games), practical food handling/preparation activities, educational displays for the classroom and parental involvement opportunities. Resources are available in both online and offline formats, and cover a range of nutrition education topics. For the NE clusters, staff members were instructed to teach two specific components of the PFP as often as possible during the 10-week period: Eat Well and Strive for 5!, then to record these activities on a checklist. Staff members were given materials to support their teaching within the curriculum covering communication and language, physical development, literacy, expressive arts and design, food preparation, and display themes. These included photo cards, posters, a floor mat, game ideas, interactive video stories, music, food preparation, tasting ideas, and drawing and coloring activities. For the Eat Well component, children learned about eating a well-balanced diet, adapted from the Eat Well guide and in

Table 1. Characteristics of preschool-aged children allocated to one of four conditions, including baseline intake of the unfamiliar vegetable (*mooli*) (N=140)

	Study Condition				
Characteristic	Taste exposure (TE)	Nutrition education (NE)	Taste exposure+ nutrition education (TE+NE)	Control	*P* value[a]
Total	47	38	39	16	
Children per preschool cluster					
Cluster 1	19	15	6	6	
Cluster 2	28	6	24	4	
Cluster 3	—	17	9	6	
Sex					0.12 (χ^2)
Male	23	23	14	10	
Female	24	25	25	6	
	←——*mean±standard error*——→				
Age (mo)	38.11±0.83	43.42±0.54	40.54±0.65	41.75±0.87	<0.001 (F)[bcd]
Body mass index *z* score	0.74±0.14	1.15±0.15	0.85±0.14	0.63±0.20	0.13 (F)
Baseline intake (g)	3.23±1.00	4.51±1.54	7.06±2.02	2.63±2.07	0.25 (F)

[a]Significant differences between groups are indicated by analysis of variance (F) and χ^2 tests, with differences between groups as follows:
[b]TE and NE;
[c]TE and control;
[d]NE and TE+NE.

Strive for 5!, children were taught about eating five portions of fruits and vegetables each day as well as the importance of eating a variety of these foods. The PFP does not contain any activities directly relating to *mooli*.

The checklist consisted of 12 activities for each of the two modules (24 possible). Using this checklist, staff members identified which of the 12 activities they used in lessons from the module and this was converted to a percentage to indicated coverage of the materials. In total, six preschools using the PFP delivered at least 35% or more of the required contents (delivery of the intervention was 100% (n=2), 50% (n=2), 40% (n=1), and 35% (n=1). Preschools in the NE clusters were able to continue accessing and delivering the PFP during the postintervention period, reflecting pragmatic and real-world delivery access.

For the TE+NE intervention, children were offered both weekly taste exposures and the education program (described above). The control condition did not receive any intervention during the study period but were offered the education program on completion of the study (after Week 36).

Data Collection and Measures

Primary Trial Outcomes. The primary prespecified outcome was weighed intake of *mooli*. All children across conditions were offered the *mooli* at four time points: baseline (Week 1), postintervention (Week 12), follow-up 1 (Week 24), and follow-up 2 (Week 36). The outcomes were measured at an individual level because factors such as body mass index, age, and eating traits may affect vegetable intake and vary among children.

Other Measures: Demographic and Anthropometric Characteristics. The investigator measured height using a stadiometer (Seca 217; Seca) and weight using a portable weighing scale (Seca 878). Body mass index *z* scores (adjusted height and weight for age) were calculated using the World Health Organization anthropometric calculator (http://www.who.int/childgrowth/software/en). Child age and sex were recorded by preschool staff members. Eating status (eater or noneater) was used as a proxy for fussiness as it is defined in relation to the child's actual behavior (ie, willingness to try the vegetable).

Intervention Evaluation Measures. As part of the process evaluation, preschool staff members were asked to complete feedback surveys regarding the intervention. Members of staff from nine preschools (excluding controls) were asked to rate the materials on the following items: acceptability, user engagement, implementation and effectiveness of the taste exposures, and/or PFP depending on condition. The survey consisted of items with a Likert scale ranging from 1 to 10 (where 1=extremely negative and 10=extremely positive).

Statistical Analysis

Descriptive statistics (mean±standard error) were generated for demographic variables and to plot the pattern of intake by condition over time. Univariate analyses of variance were used to test for differences in demographic characteristic variables across conditions. In addition, intake data were excluded from analyses where children in the TE conditions had fewer than five taste exposures (n=3). Also, for this condition because intake was measured weekly, in the case that the data were missing for the baseline (n=6) or post-intake (n=17) the child's very first or the final intake was used for the analysis. Children in the NE and control condition with missing intake data at baseline or postintervention and any children's data missing for Follow-up 1 or Follow-up 2 were excluded from the main analysis (n=75). One child who ate 121 g test vegetable at postintervention (in the TE+NE condition) was an outlier (ie, extreme value on the box plot) and was excluded from the analysis.

Because children were recruited using a cluster design, it was important to account for the influence of cluster assignment. In addition, for repeated measures, each data point was clustered within child. Therefore all the models described below corrected for this using the complex samples procedure within SPSS version 24[31] to incorporate the contribution of these variance components to the data.

Intake data for all time points resulted in a positive skew as many children ate 0 g *mooli*. Therefore, a complex samples logistic regression analysis was conducted to examine what factor predicted children eating at least some of the *mooli* (classed as eaters). Next a complex samples general linear repeated measures analysis of variance was performed to examine the predictors of the amount consumed, when children had eaten some of the *mooli*. In particular, among the children who had eaten some *mooli* at baseline, the effects of condition (TE, NE, TE+NE), time of follow-up (immediately postintervention, 3-month follow-up, 6-month follow-up), and their interactions were tested for effects on intake, controlling for age and baseline consumption.

All analyses were performed using SPSS version 24.[31] The α value was set at $P<0.05$.

RESULTS

Primary Outcomes

Intakes from baseline to postintervention for all conditions are shown in Figure 3. However, given that many children did not eat *mooli* at baseline, the data were significantly skewed and not suited to simple parametric analysis. Therefore, children were categorized according to their eating pattern at postintervention, Follow-up 1 and Follow-up 2 (noneater, eater) and these are shown in Table 2.

Logistic regression indicated that at postintervention, there was an interaction between TE and NE ($\chi^2[1]=4.67$, $P=0.031$), which indicated that children in the control condition were less likely to be eaters than in any of the other conditions (OR 0.20, 95% CI 0.05 to 0.87). In particular, children in the NE conditions had higher odds of eating the *mooli* than children who were not in the NE conditions (OR 6.43, 95% CI 1.5 to 27.8; $\chi^2[1]=5.73$; $P=0.017$). TE did not affect whether or not children were classified as eaters (OR 1.65, 95% CI 0.37 to 7.44; $\chi^2[1]=0.24$; $P=0.63$). There was no main effect of time on eater status ($\chi^2[2]=5.82$; $P=0.054$).

A second analysis was conducted to examine, only in those children who ate the *mooli*, what predicted their intake (Table 3). In this analysis, significant effects of condition were found indicating that intake increased significantly in the TE condition ($F[1,135]=11.21$; $P=0.001$). There was also a main effect of time ($F[2,134]=9.02$; $P<0.001$). There was no significant effect of NE ($F[1,135]=0.47$; $P=0.49$) and no significant interactions (largest $F=1.17$). Contrasts revealed that the significant effect of time was due to children eating more at follow-up 2 than at postintervention ($t[135]=2.20$; $P=0.029$). Overall, within the TE conditions, 10 exposures were sufficient to increase average intake by $\sim$10 g, which represents a quarter of a portion (on average) of a child's vegetable intake, or 5% of their daily fruit and vegetable recommendation. This change was maintained up to 6 months after the intervention phase.

Process Evaluation

TE Intervention Feedback. For the TE intervention, four out of five preschools reported that the intervention was easy to deliver and those four preschools also reported that children were engaged during the TE sessions. However, only two out of five preschools agreed that they were able to integrate study requirements within their normal preschool curriculum. Cost and time were the main barriers to implement repeated TE intervention in preschools. Some preschools reported that they found it challenging to get some children to try the new vegetable, and some preschools did not comply with the TE protocol because the staff continued to offer the usual snack immediately after the vegetable snack. Three out of five preschools noticed an increase in intake of the test vegetable over the intervention period. For overall experience, ratings from five preschools ranged from 5 to 10 on the 10-point Likert scale.

NE Intervention Feedback. Overall feedback for the NE intervention was very positive. All six preschools reported that the PFP resources were of a high quality. Five out of six preschools reported that resources were easy to use, easy to deliver to preschool-aged children, and engaging for the children. While five out of six preschools reported that they believed that the implementation of the NE program had an influence on healthy lifestyle awareness and knowledge of the children, four out of six preschools reported that the program did not have any influence on improving children's healthy eating behaviors. One preschool allocated to NE recognized the importance of the taste exposure technique. They commented that children did not receive enough exposure to the study vegetable and suggested improving the program by offering the children more exposure to the vegetable as part of NE.

DISCUSSION

To our knowledge, this is the first trial to examine the efficacy of both a taste exposure and nutrition education intervention delivered together or in isolation on intake of an unfamiliar vegetable in preschool-aged children. In partial support of the first hypothesis, findings from the present study confirmed that among children who ate some of the vegetable, repeated taste exposure was an effective method to increase intake of *mooli*. Thus, following 10 exposures, children who were willing to consume the vegetable at baseline learned to accept more of this vegetable over time and this was sustained long-term when offered the same vegetable again. In addition, education increased willingness to try *mooli* among children who began the intervention as noneaters. However, there was no additional benefit to overall intake in our TE+NE condition.

Children who were classified as eaters increased their intake of the unfamiliar vegetable during the post-intervention period. This might be attributed to mere

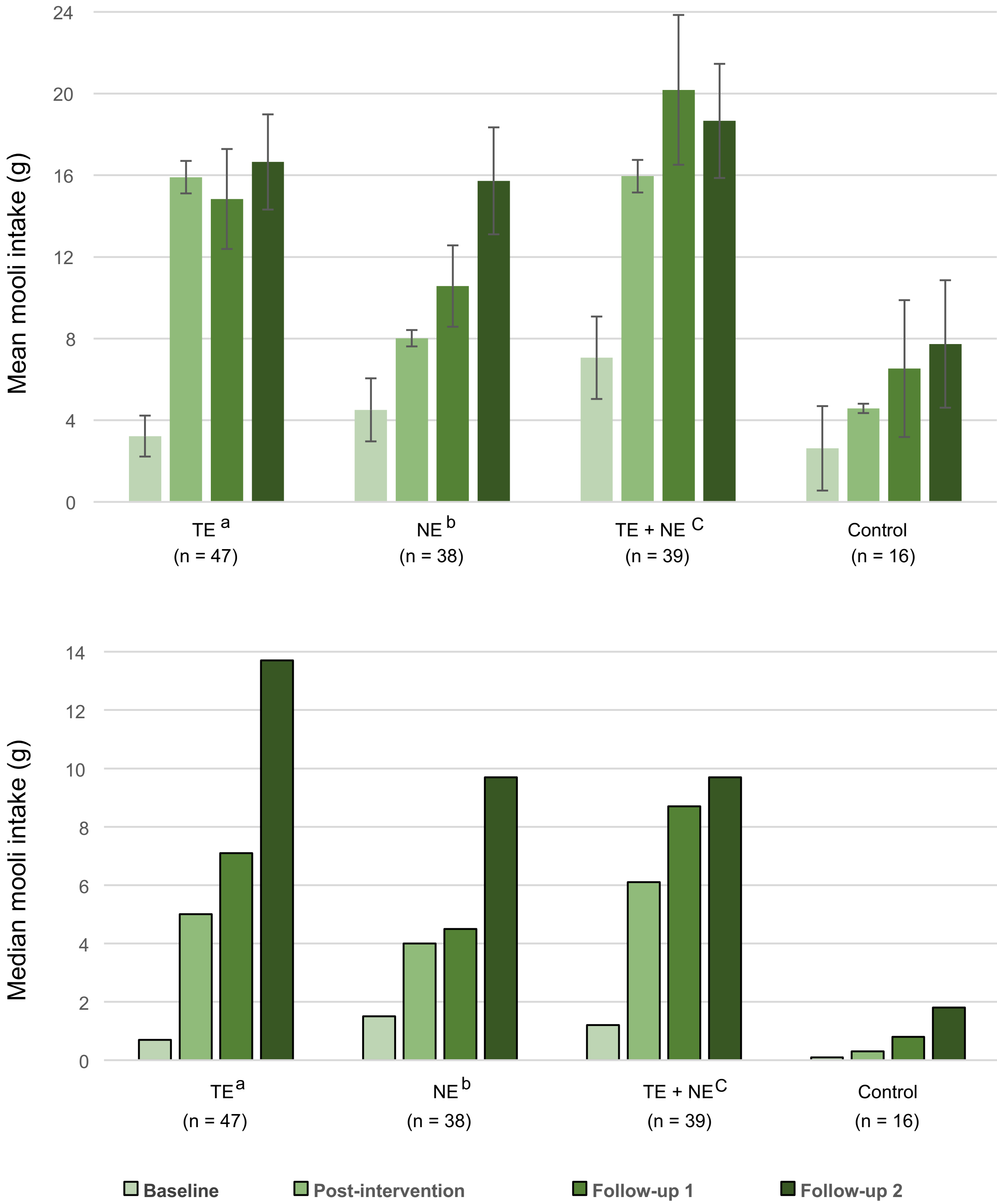

Figure 3. Intake (in grams) of the unfamiliar vegetable (*mooli*) at baseline (Week 1), postintervention (Week 12), Follow-up 1 (Week 24), and Follow-up 2 (Week 36) for all children (n = 140), shown as mean±standard deviation (upper panel) or median (lower panel). Children across all conditions increased their intake from baseline to postintervention and follow-ups. [a]TE=taste exposure condition. [b]NE=nutrition education condition. [c]TE+NE=combined taste exposure and nutrition education condition.

Table 2. Distribution of preschool-aged children by eater status across study conditions

		Study Condition							
		Taste Exposure		Nutrition Education		Taste Exposure+ Nutrition Education		Control	
Time	Status[a]	n	%	n	%	n	%	n	%
Baseline (Week 1)	Noneater	15	31.9	7	18.4	14	35.9	4	25.0
	Eater	32	68.1	31	81.6	25	64.1	12	75.0
Post-intervention (Week 12)	Noneater	3	6.4	0	0.0	4	10.3	4	25.0
	Eater	44	93.6	38	100.0	35	89.7	12	75.0
Follow-up 1 (Week 24)	Noneater	8	17.0	3	7.9	6	15.4	5	31.2
	Eater	39	83.0	35	92.1	33	84.6	11	68.8
Follow-up 2 (Week 36)	Noneater	8	17.0	4	10.5	4	10.3	4	25.0
	Eater	39	83.0	34	89.5	35	89.7	12	75.0

[a]Eater status determined as 0 g *mooli* (noneater) and >0 g (eater).

exposure effect, because by the end of the study all children had received a minimum of four exposures to the unfamiliar vegetable.[32,33] Also this could be due, in part, to the change in children's age and development, as all children were 6 months older by the final follow-up and children may become less fussy with time.[34]

Findings from the current study provide support for lasting effects of taste exposure. In contrast, a previous study by Cooke and colleagues[34] found that effects of taste exposure alone (without rewards) became nonsignificant by 3 months. These differences may be attributable to use of a previously disliked rather than an unfamiliar vegetable and to differences between using a home-based rather than a preschool setting for the study. Also, these differences suggest that rewards may be needed in the case that the effects are to endure in the home environment but may not be necessary in preschools where other motivating factors such as peer modeling and social norms are present, in line with predictions form Social Learning Theory.[35]

Nutrition education is widely used in preschools; however, the present study demonstrated that learning in a general way about vegetables is not sufficient to increase intake of an unfamiliar vegetable. Rather, it sets the scene for children to try the vegetable. Previous studies have found that learning specific to a target food, such as through visual exposure using picture books or sensory learning, can be effective in increasing intake of a target vegetable.[36,37] Therefore, there may be some benefit to combining nutrition education with experiential learning about the target vegetable with taste exposure so that a more gradual, step-by-step approach is adopted. This approach might involve a first step of introducing vegetables in a general way through nutrition education followed by experiential and sensory learning, and finally taste exposure. A more gradual approach may tackle children's food avoidance behaviors. For example, a study with children aged 7 to 9 years found that an integrated educational intervention involving taste education and culinary experience reduced children's food neophobia and increased their willingness to try novel foods.[38] Therefore, taste exposures could be integrated into existing nutrition education programs, but more work is needed to understand how the delivery of taste exposure can be improved because only two preschools in the present study were able to integrate this into their usual curriculum. The use of picture

Table 3. Amount eaten of the unfamiliar vegetable (*mooli*) among children categorized as eaters (>0 g intake) at each time point by intervention condition

	Taste Exposure		Nutrition Education		Taste Exposure+ Nutrition Education		Control	
Time	n	Intake (g) mean±SD[a]	n	Intake (g) mean±SD	n	Intake (g) mean±SD	n	Intake (g) mean±SD
Baseline (Week 1)	32	4.7±1.4	31	5.5±1.8	25	11.0±2.9	12	3.5±2.7
Post-intervention (Week 12)	44	17.0±2.7	38	8.0±1.7	35	17.8±3.1	12	6.1±2.8
Follow-up 1 (Week 24)	39	17.9±2.7	35	11.5±2.1	33	23.9±4.0	11	9.5±4.6
Follow-up 2 (Week 36)	39	20.1±2.5	34	17.6±2.8	35	20.8±2.9	12	10.3±3.9

[a]SD=standard deviation.

books highlighting a target vegetable may help to facilitate taste exposures and this is an ecologically valid method to apply in preschool settings.[11]

Strengths and Limitations

The strengths of this study include randomization, allocation concealment, reduced selection bias (by using an opt-out approach at the individual level), objective data collection, and a long-term follow-up. However, study results should be considered in the context of some limitations. First, a reasonable sample size was recruited; however, due to the nature of the study design there was a high rate of missing data over time for the complete set of intake data, including follow-ups (36%). As a result of this, there was a substantially smaller sample size in the control condition. In terms of the intervention delivery, preschools varied in the extent to which they delivered the two components of the NE program and compliance was recorded using self-report from preschool staff. This is in line with previous research that suggests that barriers exist in implementing nutrition education interventions; hence, they may be used infrequently or assigned low priority in an already crowded curriculum.[13,39-42] Nutrition education programs as used in the present study are generalizable to the real world where implementation is variable. Similarly, some preschools did not comply with the repeated taste exposure protocol because the staff continued to offer the usual snack immediately after the vegetable snack. Despite this, the effect of taste exposure was still evident in the preschool context. Future research should assess the effects of these interventions on the intake of the target vegetable as well as other unfamiliar and familiar vegetables at home. It is also important to investigate transfer effects; for example, from preschool to home and vice versa. Children's food fussiness influences eating behavior change and this can affect the success of a dietary intervention. Therefore, adjusting an intervention to suit the individual needs of children, including noneaters or fussy eaters, could improve the success of taste or education-based interventions.

CONCLUSIONS

Taste exposure is a robust and durable strategy to promote intake of an unfamiliar food. In this study, preschool-aged children who were willing to eat an unfamiliar vegetable increased their intake of this vegetable over time following intermittent exposure during snack time in a group setting. In contrast, nutrition education alone was not sufficient to increase intake of a novel vegetable. However, nutrition education was sufficient to increase willingness to taste the unfamiliar vegetable. Therefore, in future, such programs could incorporate experiential learning (including taste exposure) to encourage first steps toward tasting and eating a new vegetable.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

FUNDING/SUPPORT

This research is funded by a White Rose Doctoral Training Centre (WRDTC) Economic and Social Research Council (ESRC) Collaborative Award. The collaborative partner is Purely Nutrition Ltd. Contribution in kind, which includes storybooks and photo cards, were received from Purely Nutrition Ltd.

This study was registered at ClinicalTrials.gov, NCT03400566.

ACKNOWLEDGEMENTS

The authors thank preschool staff, parents, and children for their contribution and time in this research study. The authors also thank Alexandra Campbell from the PhunkyFoods Programme for writing the story for the storybooks.

AUTHOR CONTRIBUTIONS

C. Nekitsing, P. Blundell-Birtill, and M. M. Hetherington formulated the research questions and designed the study and were responsible for study oversight. C. Nekitsing conducted the research. C. Nekitsing and P. Blundell-Birtill performed the statistical analysis. C. Nekitsing drafted the manuscript and all authors contributed to this. All authors read and approved the final manuscript.